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Bathina et al.

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(54) **MICROMIXER OF TURBINE SYSTEM**

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F23R 3/16	(2006.01)
F23R 3/54	(2006.01)

(52) **U.S. Cl.**
CPC . ***F23R 3/045*** (2013.01); ***F23R 3/16*** (2013.01); ***F23R 3/54*** (2013.01)

(58) **Field of Classification Search**
CPC F23R 3/04; F23R 3/045; F23R 3/16; F23R 3/24; F23R 3/286; F23R 3/32; F23R 3/40; F23R 3/54
See application file for complete search history.

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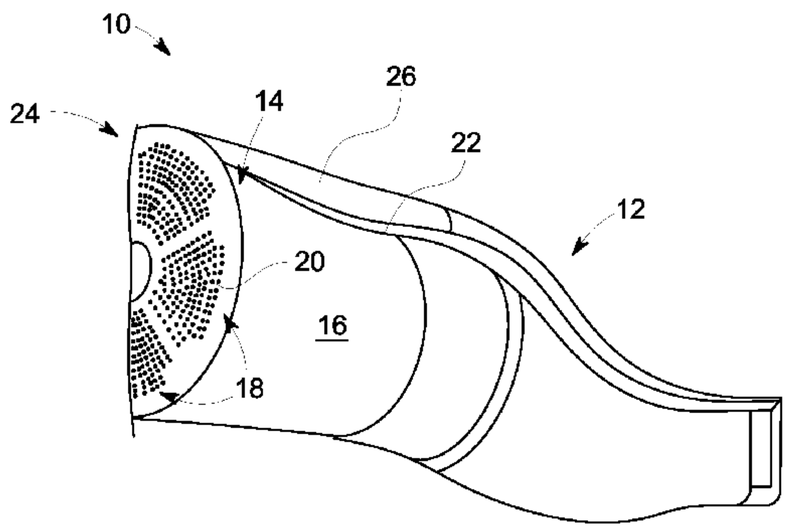
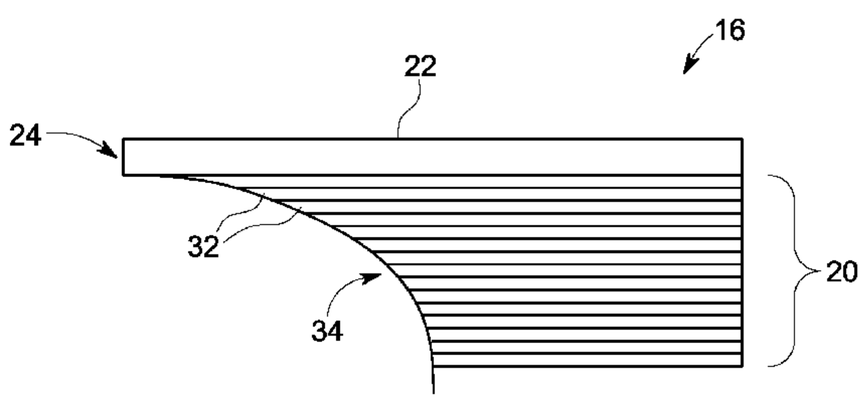
(57) **ABSTRACT**

A micromixer of a turbine system is provided and the micromixer includes a plurality of pipes each having an inlet and an outlet for receiving flow and dispersing the flow to a combustor. Also provided is a non-uniform inlet arrangement defined by the inlets of the plurality of pipes, wherein at least one of the inlets extends to an axial location distinct from at least one other inlet.

7 Claims, 4 Drawing Sheets





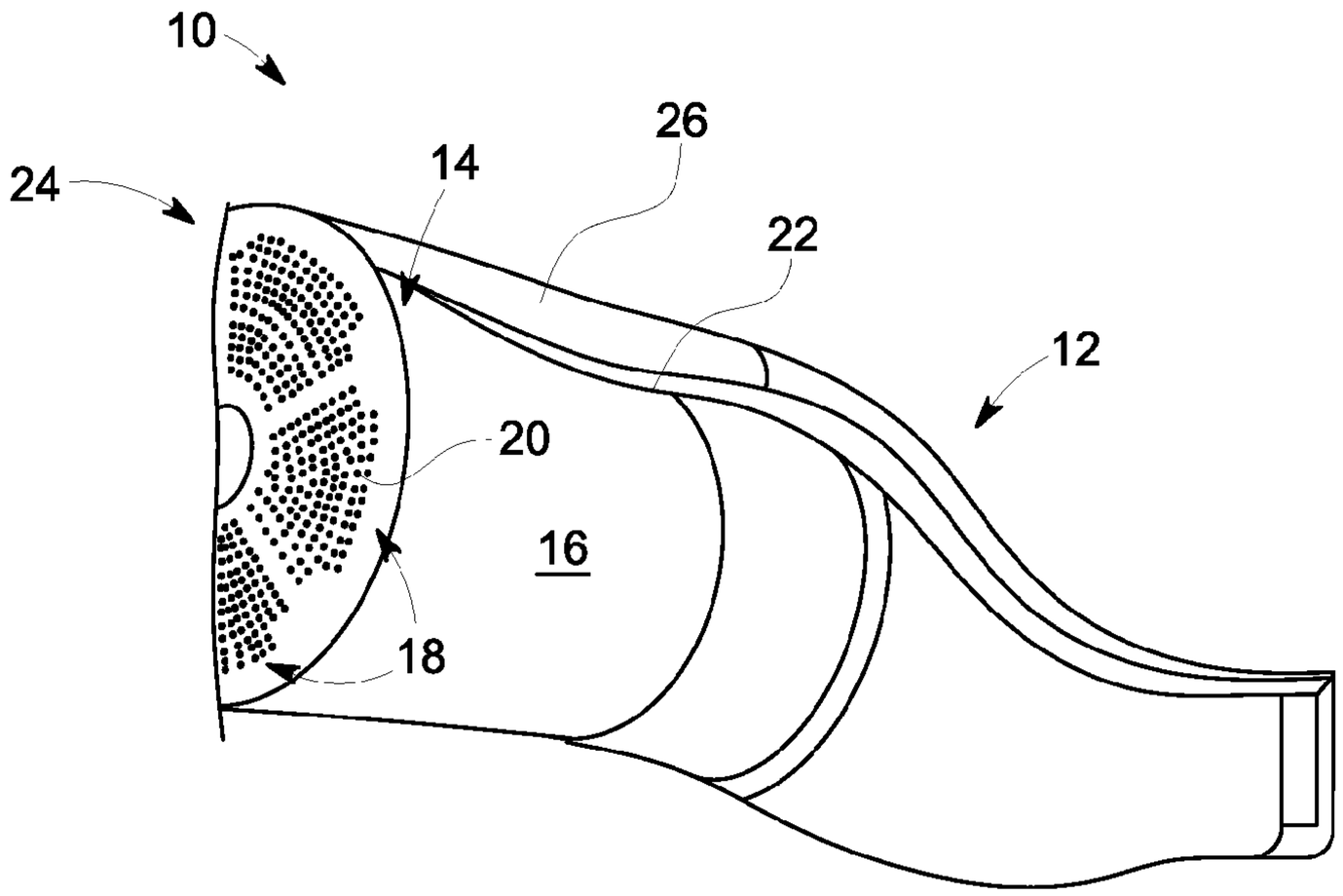
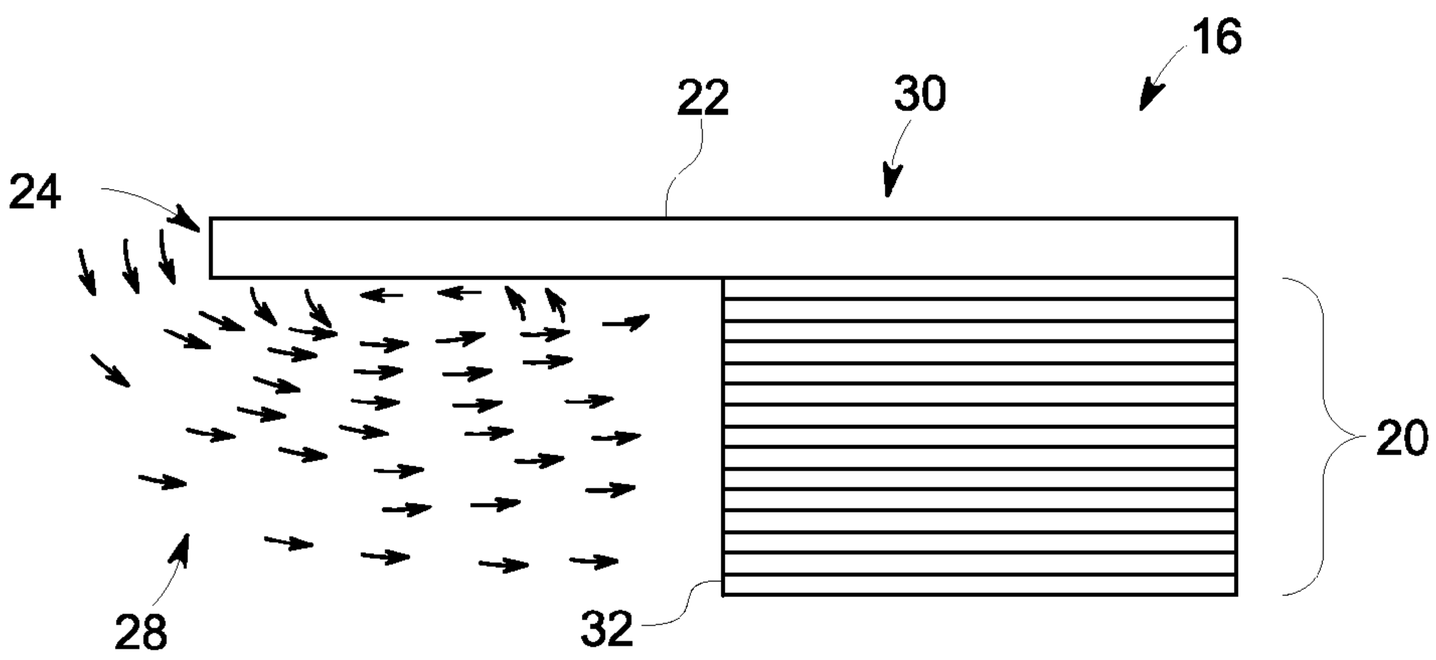


FIG. 1



PRIOR ART

FIG. 2

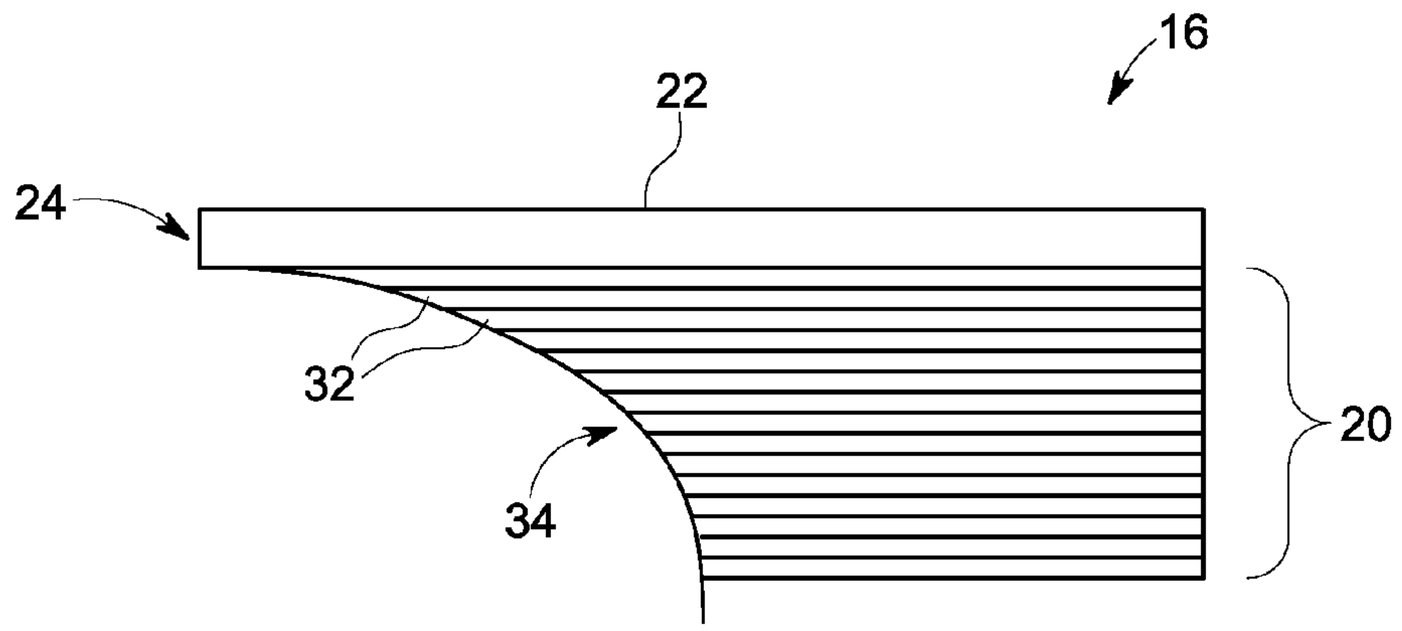


FIG. 3

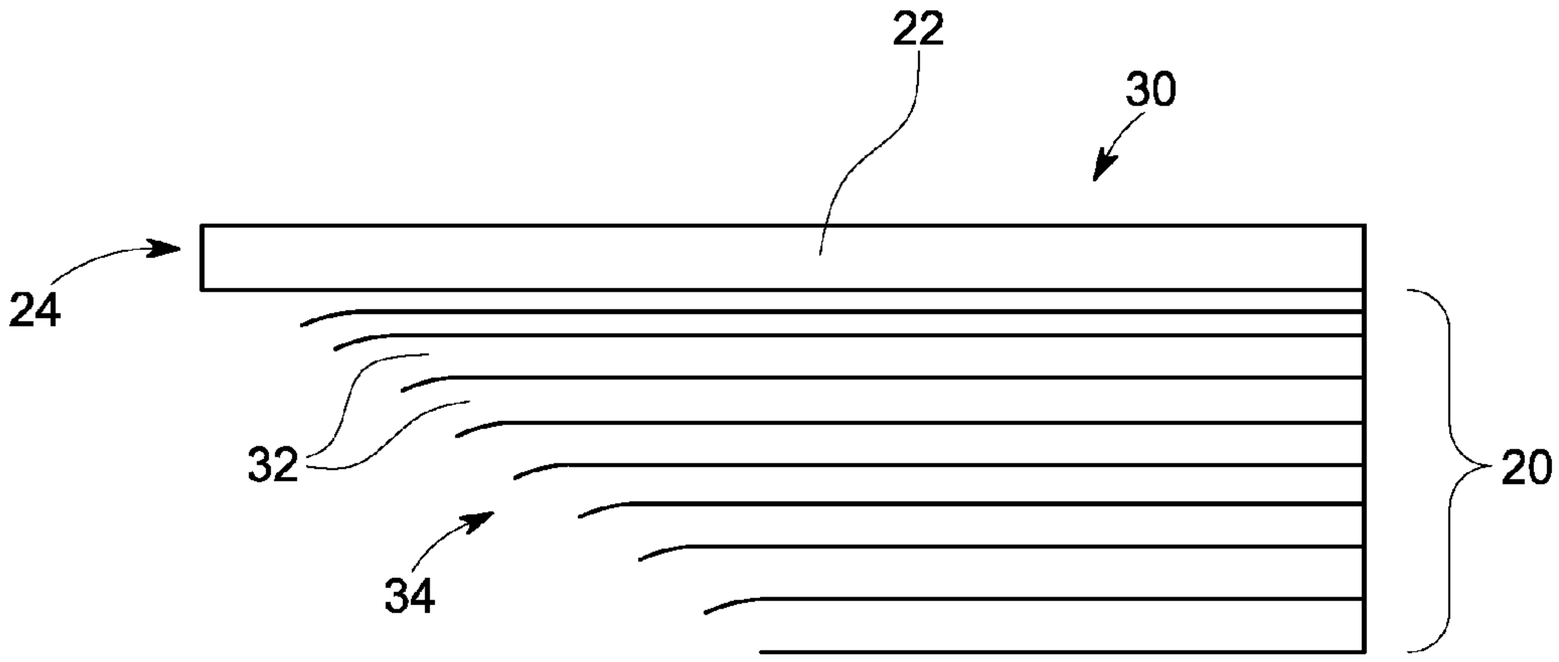


FIG. 4

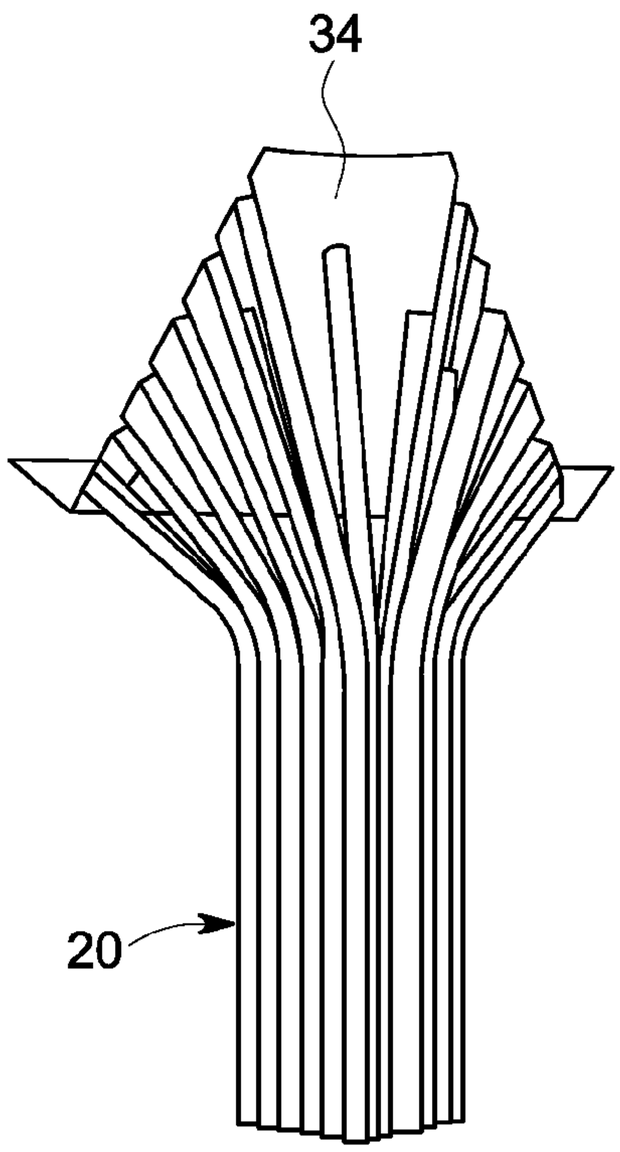


FIG. 5

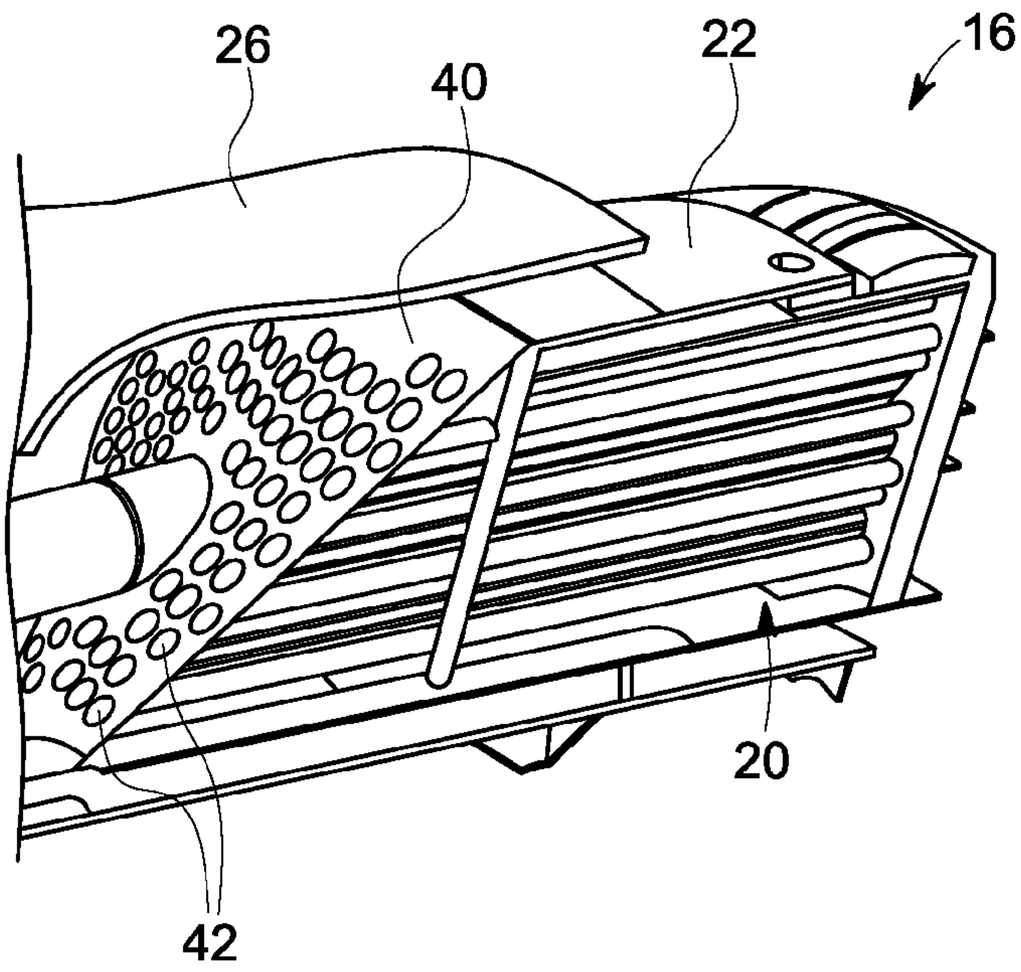


FIG. 6

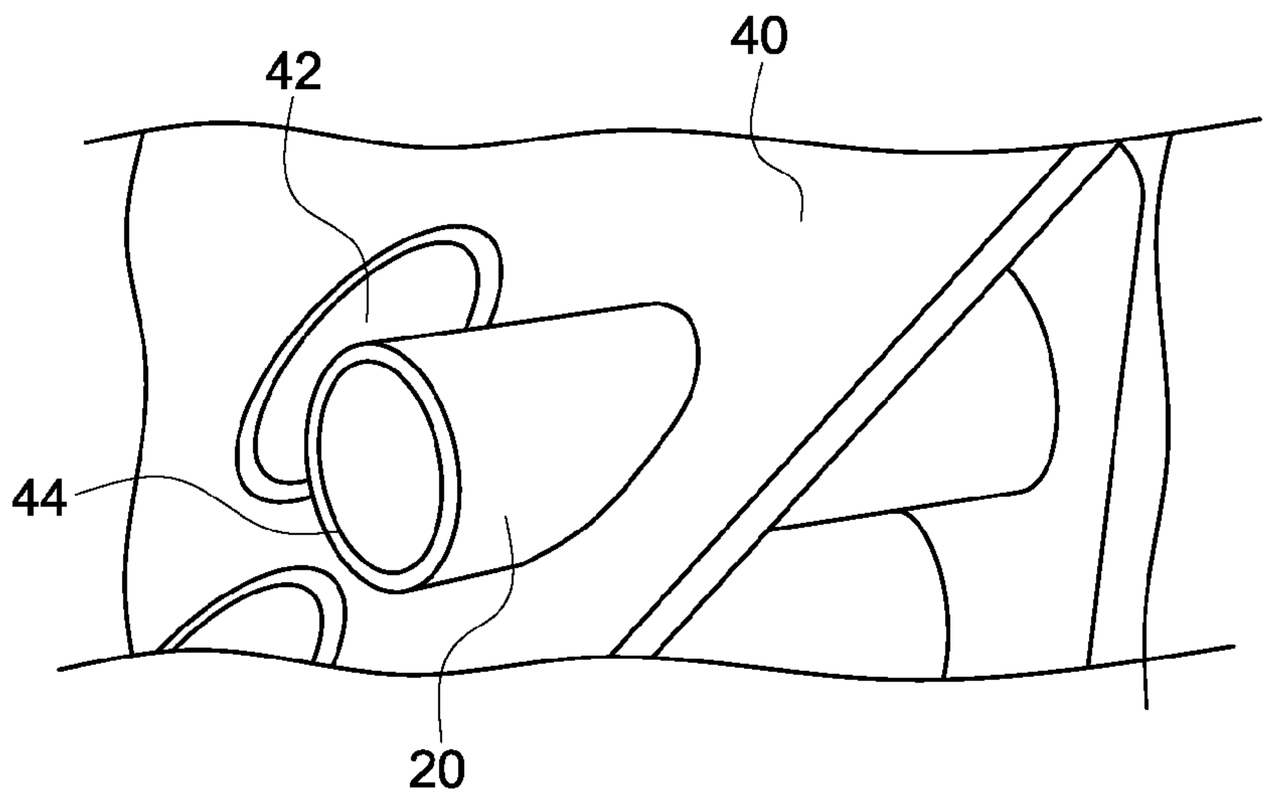


FIG. 7

MICROMIXER OF TURBINE SYSTEM

BACKGROUND OF THE INVENTION

The subject matter disclosed herein relates to turbine systems, and more particularly to a micromixer.

Turbine systems may include a micromixer, where air distribution to an individual air-fuel pipe should remain at a mean average value of the overall flow. The micromixer typically includes a plurality of pipes or tubes, each having an inlet, where the plurality of inlets are all located in a single, defined axial plane. Due to upstream conditions, such as the flow experiencing a sharp turn just prior to entering the inlets, non-uniform mass flow often prevails, thereby hindering overall system performance.

BRIEF DESCRIPTION OF THE INVENTION

According to one aspect of the invention, a micromixer of a turbine system includes a plurality of pipes each having an inlet and an outlet for receiving flow and dispersing the flow to a combustor. Also provided is a non-uniform inlet arrangement defined by the inlets of the plurality of pipes, wherein at least one of the inlets extends to an axial location distinct from at least one other inlet.

According to another aspect of the invention, a turbine system includes a combustor having an outer liner. Also included is a flow sleeve surroundingly enclosing the outer liner proximate a head end of the combustor, wherein air flows upstream between the flow sleeve and the outer liner. Further included is a micromixer disposed proximate the head end and including a plurality of pipe inlets, wherein the plurality of pipe inlets define a non-uniform inlet contour.

According to yet another aspect of the invention, a turbine system includes a combustor. Also included is a micromixer disposed proximate a head end of the combustor, the micromixer including a plurality of pipes each extending along a longitudinal axis, each of the plurality of pipes extending along a longitudinal axis, each of the plurality of pipes having an inlet and an outlet. Further included is a transverse plane aligned relatively perpendicular to the longitudinal axis and located proximate to at least one of the inlets of the plurality of pipes, wherein at least one inlet of the plurality of pipes extends upstream through the transverse plane, thereby defining a non-uniform inlet arrangement.

These and other advantages and features will become more apparent from the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWING

The subject matter, which is regarded as the invention, is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. **1** is a perspective view of a turbine system having a micromixer located in a head end;

FIG. **2** is a side elevational view of a flow preparing to enter a plurality of pipes of the micromixer;

FIG. **3** is a side elevational view of an embodiment of the micromixer having pipes of varying lengths;

FIG. **4** is a side elevational view of an embodiment of the micromixer having non-linear pipes;

FIG. **5** is a top plan view of the micromixer having non-linear pipes of FIG. **4**;

FIG. **6** is a perspective view of an embodiment of the micromixer including an angled face having a plurality of elliptical apertures that align in a flush relationship with a plurality of inlets of the plurality of pipes; and

FIG. **7** is an enlarged perspective view of an embodiment of the micromixer including the angled face, wherein the plurality of inlets of the plurality of pipes extend through the apertures.

The detailed description explains embodiments of the invention, together with advantages and features, by way of example with reference to the drawings.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. **1**, illustrated is a turbine system **10** having a combustor section **12** and a head end **14**. The head end **14** is disposed at an adjacent upstream location of the combustor section **12** and includes a micromixer **16**. The micromixer **16** includes a plurality of sectors **18** that each comprise a plurality of pipes **20**. The combustor section **12** is defined by an outer liner **22** that extends to an upstream end **24**. Spaced radially outwardly of the outer liner **22**, and surroundingly enclosing the outer liner **22**, is a flow sleeve **26**. A flow **28** of air passes upstream within an air passage **30** defined by the outer liner **22** and the flow sleeve **26** to the upstream end **24** of the outer liner **22**.

Referring to FIG. **2**, upon reaching the upstream end **24** of the outer liner **22**, the flow **28** makes an abrupt turn just prior to entering the micromixer **16**. The plurality of pipes **20** each include an inlet **32** for receiving the flow **28**. It is apparent that pipes disposed at an outer region of the plurality of sectors **18** (i.e., proximate the outer liner **22**) do not receive the flow **28** at a pressure or flow rate comparable to that of pipes disposed proximate a central region of the plurality of sectors **18**, due to the abrupt turn necessitated by the arrangement illustrated in FIG. **2**.

Referring to FIG. **3**, the inlets **32** of the plurality of pipes **20** extend upstream to various axial locations. In the illustrated example, a non-uniform inlet arrangement **34** in the form of a parabolic formation results from the varying inlet **32** extension. Such an embodiment reduces the formation of vortices present in the flow **28** after making the abrupt turn, thereby resulting in a more uniform overall mass flow throughout the plurality of pipes **20**. The parabolic formation induces pressure differences seen at the inlet **32** of the plurality of pipes **20**. The non-uniform inlet arrangement **34** may be manipulated and fine-tuned to produce a uniform mass flow throughout the plurality of pipes **20**.

Referring to FIGS. **4** and **5**, it is shown that in addition to a non-uniform inlet arrangement **34** that includes a variance of the axial location for the inlets **32** of the plurality of pipes **20**, an introduction of curvature on the plurality of pipes **20** proximate the inlets **32** enhances overall mass flow uniformity throughout the micromixer **16**. This is achieved by angling regions of the plurality of pipes **20** proximate the inlets **32**, thereby forming angled inlet portions **36** that are aligned to more capably receive the flow **28** in a manner that does not result in unnecessary pressure drops throughout the respective pipes **20**.

Referring to FIG. **6**, an embodiment of the micromixer **16** is illustrated having an angled face **40** that includes a plurality of apertures **42**. The plurality of apertures **42** are aligned to receive at least a portion of the inlets **32** of the plurality of pipes **20**. The angled face **40** is oriented such that pipes proximate an outer region of the sector **18** are shorter in length than that of pipes proximate the more radially inward pipes. The angled face **40** improves uniformity of air distribution

into the head end **14** by allowing the flow **28** to avoid taking an abrupt turn into the head end **14** region, instead making the transition more gradually and providing a more uniform distribution of the flow **28**, while reducing pressure drop throughout the plurality of pipes **20**.

In the illustrated embodiment, the inlets **32** of the plurality of pipes **20** extend to meet the plurality of apertures **42** in a flush manner, such that each surface of the inlets **32** slopes in a downstream direction as each surface moves radially outward. This configuration provides for the flush relationship between each inlet **32** surface and corresponding apertures **42**. The flush relationship between the inlet **32** and the plurality of apertures **42** causes the inlet **32** geometry to be relatively elliptical.

Referring to FIG. **7**, an embodiment of the micromixer **16** having the angled face **40** is shown. Similar to the embodiment described with respect to FIG. **6**, the angled face **40** includes the plurality of apertures **42** that are configured to receive the inlets **32** of the plurality of pipes **20**. In this embodiment, a surface **44** of each inlet **32** is flat and in a single plane that is substantially perpendicular to a longitudinal axis of the respective pipe. Rather than forming a flush relationship where the inlets **32** extend only to the plurality of apertures **42**, the inlets **32** extend beyond the plurality of apertures **42** to an axial location upstream of the respective apertures **42**, thereby forming circular entries to the plurality of pipes **20**.

Although the angled face **40** described and shown in FIGS. **6** and **7** have a specific direction of angulation, that being less than relatively 90 degrees between the angled face and the longitudinal axis of the plurality of pipes **20**, it should be appreciated that the angle of the angled face **40** may vary. Additionally, the angled face **40** may not necessarily be disposed in a single plane, instead taking on any contoured shape that provides a suitable approach for the flow **28** into the micromixer **16**.

The micromixer **16** embodiments described above advantageously provide enhanced uniformity for head end **14** flow distribution into the plurality of pipes **20**, as well as a reduction in pressure drop seen across the plurality of pipes **20**. These benefits result in more uniform fuel-air mixing and an improvement in overall turbine system **10** efficiency.

While the invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

The invention claimed is:

1. A micromixer of a turbine system comprising:

a plurality of pipes each having an inlet and an outlet for receiving a flow and dispersing the flow to a combustor; and

a non-uniform inlet arrangement defined by the inlets of the plurality of pipes, wherein the inlets of the plurality of pipes are arranged in a parabolic formation such that a longest one of the plurality of pipes is radially outermost from a centerline of the micromixer and a shortest one of the plurality of pipes is closest to the centerline.

2. The micromixer of claim **1**, further comprising a plurality of pipe sectors, each of the plurality of pipe sectors including a portion of the plurality of pipes.

3. A turbine system comprising:

a combustor having an outer liner;

a flow sleeve surroundingly enclosing the outer liner proximate a head end of the combustor, wherein a flow travels upstream between the flow sleeve and the outer liner; and

a micromixer disposed proximate the head end and including a plurality of pipe inlets, wherein the inlets of the plurality of pipes are arranged in a parabolic formation such that a longest one of the plurality of pipes is radially outermost from a centerline of the micromixer and a shortest one of the plurality of pipes is closest to the centerline.

4. The turbine system of claim **3**, further comprising a plurality of pipe sectors, each of the plurality of pipe sectors including a portion of the plurality of pipe inlets.

5. The turbine system of claim **3**, wherein the outer liner includes an upstream axial end, wherein the flow passes over the outer liner and around the upstream axial end.

6. The turbine system of claim **5**, wherein at least one of the inlets extends axially to the upstream axial end of the outer liner.

7. A turbine system comprising:

a combustor;

a micromixer disposed proximate a head end of the combustor, the micromixer including a plurality of pipes each extending along a longitudinal axis, each of the plurality of pipes having an inlet and an outlet; and

a transverse plane aligned relatively perpendicular to the longitudinal axis and located proximate to one of the inlets of the plurality of pipes, wherein each of the plurality of pipes extends upstream through the transverse plane to a respective pipe inlet located at an axial location that is distinct from every other pipe inlet, thereby defining a non-uniform inlet arrangement comprising a parabolic formation such that a longest one of the plurality of pipes is radially outermost from a centerline of the micromixer and a shortest one of the plurality of pipes is closest to the centerline.

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